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4

HYDRO-ELECTRIC POWER COMMISSION

of the

Province of Ontario

FOURTH REPORT

OTTAWA VALLEY AND ST. LAWRENCE RIVER DISTRICT

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Printed by Order of the Legislative Assembly of Ontario.
March 15th, 1907

HYDRO-ELECTRIC POWER COMMISSION

of the

Province of Ontario

FOURTH REPORT

OTTAWA VALLEY AND ST. LAWRENCE RIVER DISTRICT

Printed by Order of the Legislative Assembly of Ontario.
March 15th, 1907

698791

COMMISSION

HON. ADAM BECK, London, Chairman.
GEO. PATTINSON, M.P.P., Preston.
JOHN MILNE, Hamilton.

STAFF—

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S. B. Clement	*Asst. Engineer.*
E. Richards	*Electrical Engineer.*
H. G. Acres	*Hydraulic Engineer.*
E. C. Settell	*Secretary.*

FOURTH REPORT.

OTTAWA VALLEY AND ST. LAWRENCE RIVER DISTRICT.

To his Honour,
The Lieutenant-Governor of Ontario:—

The undersigned Commissioners appointed by your Honour by Commission bearing date the 26th day of January, 1906, beg leave to submit the following report, as their fourth report upon the matters authorized and directed to be enquired into.

Your Commissioners made enquiries and obtained information from various sources, but did not find it necessary to hold formal sittings in this district, as the information which they have obtained has been given freely to members of their engineering staff, who have thoroughly canvassed this district both as to its hydraulic possibilities and its present industrial demands.

Your Commissioners have foreborne to give in detail the names of their informants or the particulars of the information acquired from them, but have used the knowledge and facts so acquired for the purposes of computation, comparison, etc., and for the production of the results which they have now the honour to report.

The detailed scientific and technical information obtained has been tabulated and arranged by the Engineer employed by your Commissioners and is contained in his report which is submitted as an appendix hereto.

The following are the matters on which your Commissioners were authorized and directed to report, with the report upon each subjoined:—

DEMAND FOR ELECTRIC POWER.

(1) *"The present and probable demand for hydraulic and electrical power in the various districts capable of being supplied from the different water-powers within the jurisdiction of the Province of Ontario."*

In this fourth report your Commissioners deal with that portion of the Province of Ontario which lies east and north of the territory already similarly dealt with in the second and third reports already issued, and which, for the purposes of this report, may be called the Ottawa Valley and St. Lawrence River District. (See map accompanying this report.)

For convenience, the towns in this district have been assembled into three groups, but the grouping has no special significance, being geographical only.

The demand for electrical power will, in almost all cases, depend upon the relative cost of electricity as compared with that of steam, gas or other local source of power. The cost of electricity is dependent upon the distance over which it is transmitted and upon the quantity transmitted. As it is only feasible to transmit the power in large quantities, trunk transmission lines capable of carrying large quantities must be constructed at the outset; therefore the cost increases with the distance, and a point is eventually reached at such a distance from the generating station that electrical can no longer compete with steam or other local power.

Again the exhaust steam and heat from the steam plant of some factories is used in the process of manufacture, and it could not be expected that electricity would be adopted by manufacturers of this class for power only, as their production of steam and heat for manufacturing purposes apart from power would increase rather than diminish their expenses; and in many instances waste material is used in the production of steam; such industries have been excluded from the consideration of the extent of the market at present in sight. The capital cost of abandoning steam plants would also, in many cases, be considerable, and the ability of small users of power to bear this loss must always be a factor in the finding of a market.

Experience shows that where the distribution is controlled by private corporations, the distribution area remains restricted, and from the information obtained by your Commissioners they are able to say that the trend of affairs with private corporations has been, not to compete for business and thus keep down prices for consumers, but to amalgamate or otherwise destroy competition, and then to fix the prices according to the slight saving which they may be able to induce particular customers to make. The natural result of this has been to force individual consumers, where the circumstances justified it, to instal generating plants of their own, or to adhere to existing methods, rather than place themselves at the mercy of large combinations formed for the purpose of preventing competition and keeping up the price of electrical power.

An examination of the Engineer's appendix Tables I., II. and III. will show that over the greater part of this district, hydraulic power is in an advanced state of development, there being 13,000 H.P. used direct in mills, etc., and 14,000 H.P. devoted to the production of electricity, in addition to which there are several power stations having permanent works of somewhat greater capacity, ready for the installation of additional machinery.

On the other hand, it is significant that, in several localities, the adjacent water powers are fully developed and further progress is temporarily checked by the necessity of developing more distant water powers to meet further demands, and evidently, unless these demands are of considerable immediate extent, there is a hesitancy on the part of private companies to enter a field already partially or almost entirely supplied from a source of power which has reached its limit. Considerable transmission systems may be expected in this district in the near future, particularly in the new mining field adjacent to Lake Temiskaming.

As a result, however, of your Commissioners' enquiries in the various manufacturing centres of this district as to the present and probable market for electrical power, it appears that under favorable conditions a total demand of 6,400 H.P. is at present existent, but that, of this total, a considerable proportion can be supplied locally or by transmission systems, already under construction or constructed: and again in some small towns at a distance from other towns requiring power and distant also from water powers, there does not appear to be any opportunity to meet the small probable demands, until such are augmented by some special requirement of considerable extent.

To meet the demands at present existing in certain towns, however, the Commissioners' Engineer has studied the grouping of these towns in relation to certain water powers at present undeveloped. In the Commissioners' second report it was suggested that Kingston should obtain electrical power from the water powers of the Trent river, but as an alternative and, as a means of enabling Gananoque to receive similar benefits, a source of power at Waddington, N.Y., (opposite Morrisburg) could be drawn upon, to meet the requirements of Kingston, Gananoque, Prescott, Brockville and Cornwall. This development is capable of generating 15,000 H.P., but owing to the fact that the source of power is in United States territory, no estimate thereon included in this report. Assuming that Kingston and Cornwall could be otherwise provided for, a limited development has been estimated upon, for the supply of electrical power to Prescott and Brockville.

Similarly, High Falls on the Mississippi river may be developed either for the requirements of Perth, Smith's Falls and Carleton Place only, or by careful storage, the capacity may be increased so as to meet the present needs of Brockville and Prescott also, and studies have been made for such developments. Any of the investments indicated would be in stable communities in which the demands for power are certain to increase from year to year.

In the mining district adjacent to Cobalt, there is a present large market for electrical power for use in mines, and doubtless this market will tend to increase for some years, but while there are ample undeveloped water powers on the Montreal river to meet the requirements of such a market, your Commissioners do not suggest a large development at present, until it has been more fully demonstrated that the market mentioned is sufficiently stable to warrant large investments.

Should the Iroquois, High Falls and Fountain Falls developments be undertaken, there would, in the opinion of your Commissioners, be an immediate market for some 4,000 H.P., provided the power is offered at reasonable and attractive rates, but considering the insecurity of the future, it would appear that a somewhat higher rate for power in the Cobalt mining district should be considered justifiable, than would be the case in firmly established communities with diversified industries and resources.

UNDEVELOPED LOCATIONS.

(2) *"The location, capacity and capital cost of development of the various water powers within the legislative jurisdiction of the Province of Ontario at present undeveloped, but whose development is required to supply the present and probable needs of the surrounding districts, and to ascertain the cost of the attendant transmission plant necessary to the utilization of electrical and hydraulic powers to be provided from the aforesaid water powers within the respective surrounding districts."*

A systematic tabulation of the water powers of the various rivers in this district based upon gaugings and meterings, supplemented by information derived from other sources, has been carried out during the past eighteen months, and although more minute information, particularly with reference to dry weather flow, could be obtained by continuing the work, it is felt that a fairly accurate hydraulic knowledge of the district has been obtained.

Along the St. Lawrence river, which has no laterals in this part of Ontario, except a small stream at Gananoque, a peculiar situation has been created by the construction of the various ship canals.

These canals can be used to a limited extent as head races for power developments, but evidently extensive use is objectionable to the navigation interests, due to the creation of currents, and therefore no very extensive constructions of this type need be expected. The St. Lawrence has enormous potential water powers, and the future outlook in this locality would seem to be in the nature of very extensive developments, possible only by placing dams in the main river, or else, as at Hoople Creek, near Cornwall, by means of an expensive head canal, circumventing and not interfering with the ship canals themselves.

The Ottawa river and its tributaries is a magnificent source of water power, and whilst the construction of the Georgian Bay and Ottawa ship canal would create conditions more favorable than at present to such water powers, both as to first cost of construction and freedom from ice trouble of operation, still, even under present conditions, the possibilities are very great.

The Ottawa river itself abounds in opportunities, which will be taken advantage of as soon as the mineral and timber resources of its watershed are more fully exploited, but the attendant first investments will be heavy, owing to the large volumes of water to be handled, and nothing short of permanent constructions on a large scale should be encouraged.

The tributaries of the Ottawa in Ontario are less valuable as sources of water power than those in Quebec Province, but being in some cases, as on the Rideau and Mississippi rivers, easily developed, have made considerable progress. On the other hand, the Madawaska, Petawawa, Bonnechere and Montreal rivers abound in undeveloped water powers of considerable magnitude, and as the sources of these rivers are in forest areas abounding in lakes, the regulation is very good and dry weather flow higher than normal.

Water powers developed in the Ottawa districts may be looked upon as good permanent investments from an hydraulic standpoint.

Table IV. of the Engineer's report gives the dry-weather continuous capacity of the various water powers of the district. An examination of this table will show the widespread and valuable latent sources of energy waiting for investment and use.

Your Commissioners in studying in detail the cost of developing and distributing electrical power have indicated the possibilities only as regards immediate requirements, in their consideration of Iroquois, (St. Lawrence), High Falls (Mississippi) and Fountain Falls (Montreal), and an examination of Table VI. will show that these are by no means large constructions.

The Mississippi river has other valuable water powers adjacent to High Falls and the Montreal river has 12,000 H.P. adjacent to the Cobalt mines.

In general, it may be said that, with the exception of a small area, lying between the St. Lawrence and Ottawa rivers and east of Smith's Falls, the whole district covered by this report is bountifully supplied with water powers capable of being developed for reasonable costs per horse power.

RATES AND PRICES.

(3) *"To ascertain the rates or prices that would require to be charged the various classes of consumers of hydraulic or electrical power within the respective districts in order to meet all expenditure of maintenence and operation."*

The ascertainment of the rates that would require to be charged for electrical power in order to meet expenditure of maintenance and operation is based upon the cost of necessary plant, for future calls upon it, original cost of construction, cost of maintenance and operation, and the probable market for electrical power, ascertained from local enquiries.

In order to ascertain the cost of delivering electrical energy in large quantities at particular distances, where now required, your Commissioners have made computations with respect to certain available markets, which may be conveniently and economically supplied from four generating plants through transmission systems and substations, estimated upon in Part V. of the Engineer's report attached. It should be particularly noted that the basis of estimate is not the total present steam power used by the various industries, but that portion which the Commissioners' engineers, after consideration, denote as being probably available for conversion to electrical power, if such power were offered at reasonable rates.

Your Commissioners call attention to the fact, however, that when electricity is delivered at a municipal sub-station, as above, the cost of distribution among the consumers within such municipality must be added to this price in order to determine the cost to the individual municipal consumer.

In order to illustrate the cost of distributing power delivered at a sub-station, your Commissioners have caused estimate to be made for a distribution system for the town of Brockville, as this town already owns its own lighting station, etc., and in Part VI. of the Engineer's report will be found the results obtained, but it must be understood that local conditions, the proportionate amounts of lighting and power used, the variety of industries, hours of operation, etc., all point to the necessity of special local studies being made for each municipality and particular attention is directed to the fact that these estimates are based on all the power generated being used, and until such is the case, a correspondingly higher charge must be made to meet higher charges on investment, etc., etc.

Table XXII., Part V., also gives data in regard to the cost of supplying a particular customer with power at a considerable distance from a sub-station, the total cost to such consumer being the sub-station cost added to the secondary cost given in the table.

SAVINGS.

(4) *"To enquire into and ascertain the annual savings accruing to the consumers in the various districts aforesaid by the substitution of the rates or prices in the next preceding paragraph for the rates paid at present in the said district so far as the Commissioners may be able to ascertain or estimate them."*

The saving which any customer may obtain by the introduction of electrical energy on the basis of the Engineer's estimates depends on the conditions under which he is at present operating.

The customer may now be operating by steam, in which case he must consider his present total fixed charges, as well as cost of operation and then decide that he will allow his present plant to be scrapped, or keep it as a standby or reserve, to all of which must be added the cost of a motor installation, as per Table XIII., Part VII.

If, on the other hand, a customer is already using electrical power or light, the prospective saving may consist in changing from a private company source with rates based on what the business will stand to a municipal source based on the cost of service, or if the municipality is already distributing electricity generated from coal (as for instance Brockville), then the prospective saving will be the lessened cost of power to the municipality based on a cheaper source of supply.

An intelligent study of tables XV., XVI. and XVII. will give a proper basis of comparison when taken along with previous information contained in Engineer's report.

As to the actual rates which a municipality could afford to make when distributing power delivered in accordance with Engineer's estimates on a 4 per cent. cost basis, this will depend upon such items as the following:—Amount of 24 hour power sold, number of limited hour contracts during winter season, town pumping with reservoir capacity to carry over peak load, distance of chief customers from distributing station, etc., etc. The introduction of hydro-electric power available throughout the whole day and night makes marked changes in the industrial conditions of a town or city.

CAPITAL COST OF UNDERTAKINGS.

(5) "*To enquire into and ascertain the cash capital cost of the hydraulic and electrical power undertakings of existing companies located within the Province of Ontario, the capacity and state of development thereof.*"

Your Commissioners, following the policy outlined in their earlier reports, have not thought it necessary to consider any but the more important undertakings, where electrical energy is being generated for power, as well as lighting purposes and transmitted some distance.

A partial list of plants in the district coming under this head are Andrewsville, Mattawa, Pembroke, Perth, Renfrew and Morrisburg. The St. Lawrence Power Co. and the Hawkesbury Electric Light and Power Co. have not furnished the necessary information asked for by your Commissioners.

The plant of the Kemptville Milling Co. is located at Andrewsville on the Rideau river and supplies the town of Kemptville with light and power over a fifteen mile transmission line at 10,000 volts, three-phase. This plant has a generator capacity of 400 H.P., and the capital investment for generation, transmission, step-down transformation and local distribution is in the neighborhood of $65,000.

The Mattawa Electric Light and Power Co. have a plant on the Mattawa river, which supplies the town of Mattawa over a 3½ mile transmission line. The plant is a small one, having a present capacity of 150 H.P. The capital cost to date has been $, , including transmission and step-down transformation.

The town of Pembroke is to be supplied from a plant under construction on the Black river in the Province of Quebec. When this installation is completed, it will have a capacity of about 1,500 H.P., with a 14 mile transmission line. The estimated capital cost of the undertaking, exclusive of sub-station equipment, is about $125,000.

The town of Perth is supplied by the Canadian Electric and Water Power Co. from two generating stations on the Tay river, three and four miles, respectively, from the town. The rated capacity of the two plants is 400 H.P. The total capital cost to date is $128,000, including development, transmission and distribution.

The town of Renfrew is supplied by the Renfrew Power Co.'s plant on the Bonnechere river. The present capacity of this plant is 400 H.P., and the capital cost to date $81,000. A 500 H.P. unit, which is now being installed, will cost about $30,000 additional, making a total capital investment of $110,000 for development and distribution.

The Rapide Plat Canal is utilized by the town of Morrisburg, which, at present, has a 250 H.P. plant in operation for lighting purposes only. The capital investment in connection with this plant is $35,000. A new plant of 1,100 H.P. capacity is now in course of construction, the cost of which is estimated at $75,000.

By comparison, it will be noted that the capital costs per H.P. in this district are, as a rule, higher than those in the district covered by the Third Report. This is due in a great measure to the lower heads under which the plants mentioned in this report operate, and the greater power-house capacity necessary to accommodate low-head machinery, also probably partly due to the fact that the developments above described are of small capacity.

POWER SUPPLIED AND UNDER CONTRACT BY THE EXISTING COMPANIES.

(a) *"The quantities supplied and contracted for and the rates charged and to be charged under such contracts by these companies for hydraulic and electrical power."*

In Part III. of the Engineer's Report, Table IV. will be found listed the amount of machinery installed at various points. It will be noted that in most cases the installations are for mills, and that very important industries in all the manufacturing centres of Eastern Ontario are operated by water powers. As regards water powers developing electricity, the most important are those at Ottawa, devoted to general power, street railway and lighting, and the St. Lawrence Power Co., near Cornwall, which lights the canal and supplies power to the Stormont Electric Light & Power Co. and to mills.

The prices or rates charged for power and light in various municipalities are set forth in Part IX., Table XIV. It may be noted that the only power distributed is that derived from water power, and that the charges for light at Cornwall, although the source of power is a very economical canal water power development, are practically the highest rates given.

APPRAISEMENT OF UNDERTAKINGS.

(b) *The actual present value of the said undertakings, or such of them as may be required, after making such fair and reasonable allowances for existing conditions as in the judgment of the Commissioners seems necessary or expedient.''*

See Part V. of the Commissioners' report.

(c) *''To estimate the capital outlay, if any, necessary to complete these undertakings.''*

At the present time the Renfrew Power Co. is increasing its machinery equipment some 500 H.P. and at cost of probably $20,000 to $30,000, and will soon be able to meet any immediate demands.

At Morrisburg, the municipality is constructing an 1100 H.P. hydro-electric station to supply the tin plate works with some 800 H.P. and will probably expend $75,000; the head canal being the ship canal itself and very inexpensive head works being all that is necessary therefor.

At Cornwall, the St. Lawrence Power Co., whose electric power station is on the Cornwall canal, some 5 miles west at Mille Roches, will, it is stated, soon install additional units of machinery beyond the two 1000 K.W. machines already installed. Such machinery equipment up to 4000 K.W. total can be installed in the present building at a cost of $25 to $30 per H.P.

The Pembroke Power Co. is constructing a system for transmitting from a power station being built on Black River in the Province of Quebec. Its estimated cost is shown in Part V. of the Commissioners' report.

On the Montreal river two incipient undertakings are becoming active, one at the ''Notch,'' the second at Fountain Falls,—both proposing to meet the requirements of the Cobalt mining field and the municipal needs of Cobalt and Haileybury.

Near New Liskeard a small electric station is being built for supplying light and power. It is located on the Wabi river.

CONCLUDING REMARKS.

Your Commissioners respectfully submit that in the Central and Southern portions of the district the future needs of the various industrial centres will fully tax the capacity of the available smaller water powers, and the St. Lawrence river will need to be developed in a large way to fully meet requirements.

All over the northern portion, including the upper Ottawa valley and tributaries, there is ample water power available for generations to come, which will have a marked influence on the development of mineral and timber resources of this part of the Province.

All of which is respectfully submitted.

(Sgd.) ADAM BECK,
Chairman.

(Sgd.) GEORGE PATTINSON,

(Sgd.) JOHN MILNE.

Toronto, March 15th, 1907.

APPENDIX

TO

FOURTH REPORT

Ottawa Valley and St. Lawrence Valley District

ENGINEER'S REPORT

ON

THE GENERATION, TRANSMISSION AND
DISTRIBUTION OF ELECTRIC POWER

HONORABLE ADAM BECK,
CHAIRMAN OF THE HYDRO-ELECTRIC POWER COMMISSION:

DEAR SIR:—

Herewith find my report on the Ottawa Valley and St. Lawrence River District, extending as far north as the height of land.

The report deals with the present consumption of and demand for power, the sources of power developed or undeveloped and discusses in detail certain developments within economical transmission distance of various markets and indicates the cost of generating and transmitting the electrical energy required to meet present needs, based upon 4 per cent. return on investment.

Yours respectfully,

CECIL B. SMITH,
Chief Engineer.

TORONTO, CANADA,
JANUARY 5TH, 1907.

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Hydro-Electric Power Commission
of the
Province of Ontario

OTTAWA DISTRICT

N SHOWING TRANSMISSION LINES FROM
er Powers on the Ottawa River and
its Tributaries

Scale:- 15 Miles - 1 Inch

Nov 1906

- Transmission Lines now in Operati

PART I.

GEOGRAPHICAL SUBDIVISIONS.

The District included in this Report is that bounded on the West by the Districts treated in Reports 2 and 3 already issued, on the South by the St. Lawrence River, on the East and North by the Ottawa River, the interprovincial boundary and the height of land south of Lake Abitibi. It has been sub-divided for convenience into three portions, viz., the St. Lawrence margin, the Central Ottawa valley and the Upper Ottawa valley.

The St. Lawrence River margin, which includes that district drained to the St. Lawrence, is the site of a number of towns of considerable commercial importance. This section is very narrow and no large tributary rivers exist here. The potential water powers on the St. Lawrence itself, are, as a rule, very large and have not been developed to any great extent, excepting in such cases as were made easy by reason of canal construction carried out by the Dominion Government for purposes of navigation. The only tributary river is the Gananoque, which, at the town of that name, has been successfully developed to yield its maximum output for the needs of the Water Power Association which carried out the work.

By far the greater portion of the peninsula lying between the St. Lawrence and Ottawa Rivers is drained by tributaries of the Ottawa. The elevation of the land surface above that of the Ottawa River is not very great and there are no lakes or marshes which would serve as storage basins to supplement the dry weather flow. As a consequence, the rivers, chief of which is the Nation, are subject to very great Spring floods and to periods of very low water.

Westward of and including the Rideau river, all the tributaries of the Ottawa flow from basins containing a large proportion of lakes and marshes and thus are better suited for the development of power. The relative elevation of the hinterland, too, becomes greater towards the West, the total fall of the Madawaska for instance being over one thousand feet, as is also that of the Petawawa.

The Mattawa river, however, lies in a valley extending from the Ottawa only as far westward as Lake Nipissing, rising in this distance less than two hundred feet. North of this valley, the country, while retaining the character of that above described, has much less relative elevation and there are fewer water-powers of importance.

PART II.

DEMAND FOR POWER.

As a basis for estimates, a full canvass was made by expert assistants in each town of this District. In this canvass care was taken to enquire and if possible ascertain whether or not the manufacturer would be likely to adopt electrical power if it were available at reasonable rates. The canvass included also the present users of hydraulic and of electric power. In the tables following (Nos. I. II. and III.) there are given estimates of the amounts of power now available for substitution of electric installation and of the amounts of Hydraulic and Electric power already in service.

The map accompanying this report indicates the location of the various cities and towns in the District, as well as a few of the chief water-powers and also the specific transmission schemes which have been adopted as appearing to best serve the requirements of markets at present available.

It will be noted that but few towns have been included in the transmission schemes which follow. This is due in some instances to the fact that the local sources of hydraulic power have not been completely or economically developed and that careful use of these resources would satisfy the town's present requirements and probably those of the immediate future. In other instances it is due to the fact that the small amounts of power required would not warrant the expenditure necessary to supply the available market.

It will be further noted that in certain portions of this District, there are very large powers, for which there is no apparent available market existing. Such are many of those on the Ottawa, Madawaska and Petawawa rivers.

TABLE I.

POWER CONDITIONS.

ST. LAWRENCE RIVER DISTRICT.

Municipality.	Population.	Average Total Power Used. H.P.	Average Hydraulic Power Used Direct. H.P.	Maximum Hydro-Electric Power Developed. H.P.	Steam Power Available for Electric Installation. H.P.	Remarks.
Brockville.....	9,000	900	..	..	900	
Cornwall.......	7,600	4,485	3,300	925	40	From St. Lawrence River Power Co., Mille Roches.
Iroquois.......	1,200	85	45	100		
Gananoque.....	4,000	900	800	180	35	Gananoque Water Power Association control and distribute water available at various seasons on 10-hour basis.
Morrisburg...	1,700	200	135	267	..	Town building 1,100-h.p. plant for tin-plate works.
Prescott.......	3,035	215	..	..	150	

TABLE II.

POWER CONDITIONS.

CENTRAL OTTAWA VALLEY.

Municipality.	Population.	Average Total Power Used. H.P.	Average Hydraulic Power Used Direct. H.P.	Maximum Hydro-Electric Power Developed. H.P.	Steam Power Available for Electric Installation. H.P.	Remarks.
Hawkesbury...	4,500	2,900	1,400	800	..	Transmitted 10 miles by Hawkesbury E. L. & P. Co.
Vankleek Hill..	2,500	175	..	..	100	Light is now supplied by Hawkesbury E. L. & P. Co.
Alexandria.....	2,200	275	75	..	200	
Chesterville....	850	115	..	..	50	
Winchester.....	1,200	230	..	..	140	
Kemptville.....	1,400	90(a)	..	300	..	Lighting not included in (a.) Power transmitted 14 miles from Andrewsville
Merrickville....	1,100	350	350	40	..	..
Smith's Falls...	5,700	815	..	1,500	500	..
Perth..........	4,000	240	..	200	150	Transmitted for commercial lighting 3 and 4 miles.
Carleton Place .	4,000	505	205	185	300	
Almonte.......	3,000	865	750	225	80	Municipal plant to be enlarged.
Arnprior.......	4,300	520	380	160	170	
Ottawa........	67,600	16,075	5,250	8,650	400	Maximum.

TABLE III.

POWER CONDITIONS.

UPPER OTTAWA VALLEY.

Municipality.	Population.	Average Total Power Used. H.P.	Average Hydraulic Power Used Direct. H.P.	Maximum Hydro-Electric Power Developed. H.P.	Steam Power Available for Electric Installation. H.P.	Remarks.
Renfrew	3,500	585	170	530	150	Renfrew E. L. & P. Co. will soon enlarge plant.
Eganville	1,100	300	300	100	..	..
Pembroke	5,150	521	100	..	250	1,300-h.p. will soon be available from Waltham, P.Q., 13 miles.
Mattawa	1,700	75	50	90	..	3½ mile transmission.
Cobalt Mines	..	2,800	..	..	2,200	Demand uncertain and rapidly growing.
Haileybury	1,215	200	..	..	200	Lighting only.
New Liskeard	2,700	200	..	..	200	Lighting chiefly.
Cobalt	..	200	..	..	200	Lighting only.

PART III.

SOURCES OF HYDRO-ELECTRIC POWER.

Of the water-powers in this District, those of the St. Lawrence and of the Ottawa rivers are the largest, and for the entire development of a water power on either a complete damming of a great river bed is necessary.

The St. Lawrence being a navigable stream throughout, and, at points of possible development by the Province of Ontario, an international stream, it is not at present necessary to consider here the question of making use of these water powers in this manner. Canals paralleling each of the rapids of the St. Lawrence have been built by the Dominion of Canada, thereby concentrating at one or more points the existing heads and providing to a limited extent water supply, which has been in whole or in part, utilized in nearly every case by private interests. In the table following is given a summary of the powers along this river, (1) involving the entire estimated low water flow, and, (2) derivable from the canal waters, either by diversion to the river or by utilizing the head at the various locks. The amount of power derivable from the canal waters depends upon the dimensions of the canal section and of the various inlets and passages at the locks, and upon the allowable velocity of the canal waters, which velocity is limited by the requirements of navigation.

The Ottawa river over a considerable portion of its course is a navigable stream and its waters are, moreover, interprovincial. This latter fact need not stand in the way of the intelligent and economical development of the water powers, although it has led to difficulties in the past. In the report following, estimates of power are based on the entire low water flow of the stream at each important fall or rapid. The construction of a 23 foot Georgian Bay Ship Canal, as is proposed, would altogether alter the profile of the Mattawa and Ottawa Rivers and would concentrate the entire fall of these rivers at the various necessary dams. A further result would be the reduction of the variation in the discharge of these rivers, an end desirable for canal operations as reducing the seriousness of the annual floods. Essential to such control of floods would be the damming of Lake Temiskaming and other lakes in the Upper Ottawa valley. An example of the effect of canalization and storage of flood waters may be noticed in the case of the Rideau river, the existence of whose dams and retaining works causes the discharge of the stream to be more than ordinarily regular.

In Part I., while discussing the geographical subdivisions of this district, reference was made to the fact that by far its greater portion contains many lakes and marshes. It was, moreover, thickly wooded, in time past, and in some portions even yet, with white pine and now with a dense second growth of birch, poplar, maple, spruce, etc. These conditions are likely to remain permanent, and thus the discharges of the rivers will probably retain their present character and dimensions.

Of the important Ontario rivers tributary to the Ottawa, the Nation river is peculiar in that it drains a comparatively low lying country well cleared of large timber, fairly well drained and without any lakes. Its low water flow is therefore very small and as a source of power the river has little value. The other principal tributaries have in their drainage areas numerous lakes and swamps; a few of these lakes are now under control by lumbermen, though many of the dams erected for this purpose are reaching an advanced stage of decay. For power purposes, the low water flow of the streams can be considerably increased and besides this in many cases, pondage sufficient to accommodate a peak load considerably greater than that indicated in the tables can be created in the immedate vicinity of the individual falls.

The discharge of most of these streams has been measured during the late summer and a unit rate of low water discharge per square mile of drainage area has been chosen. For the Quebec and upper Ontario tributaries, a larger unit has been selected as probably near to the truth, on account of this district being more heavily timbered, and thus the flow of the Ottawa at different points has been estimated. This is considered a fairly safe method, as the characteristics of the entire watershed, with the exception of the Nation river basin, are practically uniform.

The heads given are, in many cases, the results of approximate measurements by the commission's engineers; in others, they are derived from surveys made by other engineers, and in some cases they are taken from White's "Altitudes in Canada." The amount of fall shown in the tables as existing at any one point is a matter of arbitrary decision, as, should any given development be made, the working head chosen and the extent of existing rapids to be included should be arrived at only after a very careful estimate of the economics involved. Many lesser rapids have been entirely omitted from the lists below.

In many of those developments which have been made hitherto, the entire available head has not been made use of, for confirmation of which fact see Table IV. wherein it will be noted, as is the case at other places, that all but one of the developments at the Chaudiere Falls, Ottawa, operate under heads much less than the maximum available, thus generating a smaller amount of power than could have been obtained otherwise.

TABLE IV.

WATER-POWERS IN ST. LAWRENCE AND OTTAWA DISTRICT.

WATER POWER	Lowest Head, Feet	Estimated Low Water Flow c.f.s.	Minimum 24 Hour Power H.P.	Present Turbine Installation H.P.	REMARKS
St. Lawrence Canals:					
GALOPS,					
*†Cardinal	6	......	......	200	Edwardsburg Starch Works.
*Iroquois	14	......	......	40	M. F. Beach.
				20	Town of Iroquois pumping and electric plants.
RAPIDE PLAT,					
Morrisburg	11	1,410	1,410	......	Gibson lease, 60 H.P.
				250	Town of Morrisburg pumping and electric plants.
				1,100	New municipal lease for electric power.
CORNWALL,					
*†Mille Roches	20	......	......	2,700	St. Lawrence Power Co. Normal head 28 feet.
Lock 20	8	1,400	1,000		
Lock 19	6	1,400	760		
Lock 18	7.5	1,400	950	800	Toronto Paper Mfg. Co.
				50	Municipal pumping.
*Lock 17	20	1,400	2,540	1,500	Canada Colored Cotton Company.
				1,200	
				200	
				80	Cornwall Street Ry. and Wm. Hodge flour mill.
St. Lawrence River:					
Galops, Cardinal and Iroquois Rapids	15	170,000	232,000		
Rapide Plat	11.5	170,000	178,000		
Long Sault	40	170,000	618,000	.....	St. Lawrence River Power Co., Massena, N.Y.
a **Gananoque River**	21	190	365	50	Cowan & Britton.
				50	O. D. Cowan.
				100	The Skinner Co.
				150	Spring & Axle Co.
	14	......	......	250	Electric Light Plant.
				65	Rolling Mill.
				80	Ontario Wheel Works.
				50	Parmenter & Bullock.
				90	Toronto Bolt & Forge Co.
				60	Canada Cabinet Co.
				40	St. Lawrence Steel and Wire Co.
	7	......	......	95	Grist mill.
				20	Mitchell & Wilson.
				150	G. F. Jones.
				10	W. G. Gibson.
Ottawa River:					
Carillon Dam	16	17,400	25,300	.....	Present dam and rapids below.
Long Sault Rapids	43	17,400	65,300	1,200	Hawkesbury Lbr. Co., head developed 8 feet.
Chaudiere Falls	35	11,500	36,300	3,600	J. R. Booth, 25 ft. head.
				1,850	Ottawa Electric Co., 22 ft. head.
				2,800	Ottawa Electric Co., 25 ft. head.
				1,600	Ottawa Electric Ry. Co. 20 ft. head.
				4,000	Ottawa Power Co., 25 ft. head.
				4,000	Municipal pumping, 27 ft. head.
				7,000‡	E. B. Eddy Co., heads 16-21 ft.
				6,000‡	Ottawa & Hull Power Co., head 27-35 ft.
Little Chaudiere Rapid	7	11,500	7,300	......	
Remous Rapid	3	11,500	3,140		
Deschenes Rapid	9	11,500	9,400	2,100‡	Capital Power Co.
				1,200‡	Hull Electric Co.

TABLE IV.—Water-powers in St. Lawrence and Ottawa District.—*Continued.*

WATER POWER	Lowest Head Feet	Estimated Low Water Flow c.f.s.	Minimum 24 Hour Power H.P.	Present Turbine Installation H.P.	REMARKS
Chats Falls	38	11,100	38,400		
Chats Rapids	12	11,100	12,100		
Portage du Fort	12	9,800	10,700		
*b*Calumet Island	..	9,800			
Roche Fendu	86	4,900	38,300	.....	Interprovincial Channel, 13 miles of rapids.
Calumet Falls	55	4,900	24,500	.....	In Prov. of Quebec.
Mountain Chute	15	4,900	6,680	.....	
*b*Allumette Island	..	8,600	......	....	
Les Allumettes	13	6,600	7,800	.....	Interprovincial Channel.
Paquet's	9	6,600	5,400	.....	In Prov. of Quebec.
Culbute	21	2,000	3,800	.....	
Des Joachims	27	7,830	19,200	.....	
Rocher Capataine	41	7,130	26,600		
Deux Rivieres	13	7,080	8,360		
Trou	7	7,020	4,460		
L'Evieilles	8	7,020	5,100		
Rocky Farm, Johnson and Mattawa	17	6,950	10,700		
Les Erables Mountain	16	6,450	9,400		
Long Sault	49	6,440	28,700	.....	Six miles of rapids.
Nation River:					
Cripler	12	15	16	200	Bishop & Son flour mill and electric light plant.
High Falls	40	25	90		
Plantagenet	8	30	20	.....	Grist mill and wooler mill.
Rideau River:					
*c*From Perth, 3 miles	15	55	75	250	Electric light and power for Perth.
Tay River, 4 miles	10	55	50	250	
Smiths Falls	6	140	76	280	Electric light plant.
				90	Plough works.
	18	140	230	100	Woolen mills.
	17			300	Stove Works.
	17			500	Flour and planing mills.
	15			800	Flour mill.
	13			400	Municipal pumping.
1 mile below Smiths Falls	18	140	230	500	Smith's Falls Electric Company.
Merrickville	26	215	505	.....	Possible development.
	12	215	235	120	Electric light plant.
				100	Sawmill.
				70	Malleable iron works.
				170	Flour mill.
				50	Woolen manufacture.
				50	Ploughs and stoves.
				120	Grist and saw mills.
				80	Furniture.
Andrewsville	11	220	220	250	Kemptville elec. supply.
Manotick	10	363	330	750	Grist mills.
Black Rapids	10	370	330		
Hog's Back	50	400	1,820	.....	Saw and planing mills.
Ottawa	40	400	1,450	100	Foundry.
Mississippi River:					
King	24	140	305		
Otter	15	140	190		
Island	38	140	485		
Ragged	38	140	485		
High Falls	72	140	915		
Geddes Bros	15	140	130	.....	Grist mill.
Playfairville	15	150	200	.....	Saw mill.
Innisville	13	232	275		
Carleton Place	12	250	272	.....	Possible development.
	8	......	......	200	Elec. light stations.
				250	Four mill.
	8	250	182	.....	Possible development.
	7	......	......	70	Engines.
	7	......	......	200	Woolen mills.
Appleton	16	250	360	.....	Woolen mills.
Almonte	10	300	270	100	Flour mill.
				40	Flannel mill.
				30	Machine shop.
	51	300	1,390	500	Woolen mills.
	26	......	......	250	Municipal elec. plant.
	22	......	......	190	Dress goods, etc.
	18	......	......	75	Woolen goods.
	14	......	......	150	Shoddy mill.
	7	......	......	100	Knitting mill.

TABLE IV.—Water-powers in St. Lawrence and Ottawa District.—*Continued.*

WATER POWER	Lowest Head, Feet	Estimated Low Water Flow c.f.s.	Minimum 24 Hour Power H.P.	Present Turbine Installation H.P.	REMARKS
Rosebank	23	320	670	.....	Woolen mill. Grist mill.
Packenham	18	330	540	.....	Flour mill.
Galetta	25	345	780	35 80	Woolen mill. Grist mill privilege.
Madawaska River:					
Palmer Rapids	17	635	980		
Omo Rapids	7	650	410		
Snake Rapids	30	670	1,820		
Slate Falls	23	725	1,510		
Highland Chute	12	725	790		
Camel Chute and Rapids.	19	740	1,280	.....	Sawmill, 8 ft. head.
Colton Chute	18	750	1,230	.....	
Rapids	13	750	885	.....	
Deschenes Rapids and Rapids above	29	770	2,030	.....	
Rapids	7	770	490	.....	
Cedar Rapids	31	775	2,180	.....	
Mountain Chutes	40	790	2,860	550	Electric plant for graphite mine, 20 feet head.
Norway Chute	8	790	575	.....	
Chain Rapids	15	810	1,100		
The Ducks	16	830	1,220		
Ragged Chute	16	830	1,220		
High Falls	78	830	5,960		
Barret's Chute	17	830	1,300		
Calabogie Rapids	20	860	1,560		
Sixteen miles of Rapids, Arnprior	20	885	1,610	.....	Present dam dilapidated
	18	......	......	200	Grist mill.
	9	......	......	75	Machine shop
	9	......	......	75	Electric light plant.
	10	......	......	300	Sawmill
Bonnechere River:					
Rabitahl Cascades	405	20	730		
High Falls	30	20	55		
Eganville	14	105	135	300 120 40	Sawmill Flour mill and elec. plant. Sash factory.
	12	105	115	300	Flour mill and elec. plant.
	12	105	115	.....	In process of developm't.
Fourth Chute	46	110	460	.....	Possible development.
	15	......	......	700	Sawmill.
Third Chute	21	110	210		
Renfrew	37	140	470	500	Renfrew Power Co. (capacity being increased)
	20	140	255	100 110 300 50	Woolen mills. Sawmill and elec. plant. Renfrew Milling Co. Thos. Lowe.
	11	140	140	.....	Unused.
(Smith's Creek Branch)	44	15	60	190	Sash factory.
First Chute	32	145	420		
Petewawa River:					
1st series rapids below Catfish Lake	119	120	1,290		
2nd do.	41	120	445		
3rd do.	80	120	875		
1st series rapids below Cedar Lake	29	145	380		
2nd do.	33	145	435		
3rd do.	36	145	475		
1st series rapids below Little Trout Lake	18	190	310		
2nd do.	13	190	225		
On LaVieille Cr.	31	60	170		
2nd series rapids below La Vieille Creek	25	250	570		
3rd do.	16	255	370		
4th do.	27	255	630		
5th do.	24	255	560		
6th do.	44	255	1,000		
1st series rapids below Lake Travers	16	280	410		
3rd do. (Crooked Chute)	41	280	1,050		

TABLE IV.—Water-powers in St. Lawrence and Ottawa District.—*Continued.*

Water Power	Lowest Head, Feet	Estimated Low Water Flow c.f.s.	Minimum 24 Hour Power H P.	Present Turbine Installation H.P.	Remarks
1st rapid above S. Branch.	13	280	330		
1st rapid below S. Branch..	13	375	445		
2nd do.	18	375	615		
At C.P.R. Bridge........	21	380	725		
2nd above mouth........	24	380	830		
1st above mouth.........	21	380	725		
Indian River:					
Pembroke...............	9	30	25	......	Foster's mill.
Muskrat River:					
Pembroke...............	12	60	65	75 30	Grist mill. Woolen mill.
Mattawa River:					
Plein Chant.............	17	160	250	.....	Electric light plant.
Paresseux...............	33	120	360		
Little Paresseux.........	8	120	95		
Talon..................	42	60	230		
Montreal River:					
The Notch..............	100	750	6,500		
Fountain Falls...........	21	720	1,350		
Ragged Chute...........	36	720	2,360		
Ragged Chute and Rapids below and above.......	54	720	3,500		
Hound Chute............	18	720	1,180		
Latchford...............	8	720	510		
Mattawapika............	30	100	270		
Blanche River:					
Lot 12, Con. 3, Evanturel..	54	130	640		
Lot 1, Con. 3, Dack.......	26	130	310		
Lot 2, Con. 4, Dack......	34	130	400		
Lot 7, Con. 4, Dack......	22	130	260		
L. Wendigo Br..........	36	100	330		
1 mile below Lake Wendigo..................	36	100	330		
Wabi River:					
High Falls..............	81	30	220		
New Liskeard...........	100	30	270	200	New Liskeard Light and Power Co., under construction.

*Head least in periods of high water in the river.
†These plants take water from an upper reach of the canal and discharge it into the river.
‡Developments in Quebec Province.
*a*All consumption on 10 hour basis.
b The distribution of the discharge is uncertain and varies at different stages of the water. Certain existing dams at La Passe, Ont., and at Culbute and Bryson, Que., now control the water levels above.
*c*Upper Tay controlled for use on Rideau Canal.

PART IV.

GENERATION OF POWER.

As will be seen in the preceding tables, nearly every town in the district has electric light and power supplied from a hydraulic source. The most important developments are those of Ottawa, Cornwall, Hawkesbury, Morrisburg, Smith's Falls, Gananoque and Almonte. It may be said of most towns in this district that the local hydraulic power has been a large factor in fixing the location of the town. Several of the towns have, in their demand for electrical supply of light and power, outgrown the capacity of the early hydraulic developments and are now, or were until recently, in need of a supply from more extensive and more economical local developments, or from hydraulic sources external to themselves. In the former class are Almonte, Arnprior, Morrisburg and Renfrew; in the latter, are Carleton Place, Gananoque, Kemptville, Pembroke, Perth and Smith's Falls. Of the latter group, Kemptville is now supplied from a development at Andrewsville of a capacity of 400 H.P. by a transmission of 14 miles at 10,000 volts, and Pembroke will shortly receive a supply up to 1,300 horse power at 22,500 volts from a development at Waltham on the Black River in the Province of Quebec. Gananoque is isolated and cannot expect to receive a supply of hydro-electric power other than it now possesses unless Kingston should at some time be supplied from a hydraulic source along the St. Lawrence river. Of the former group, Morrisburg is constructing a second municipal plant and at Renfrew the privately owned Company is engaged in more than doubling its equipment of generating machinery. The Hawkesbury Lumber Company develop power under an eight foot head on the upper portion of the Long Sault Rapids on the Ottawa River, but the town itself is not supplied from a local source. The Hawkesbury Electric Light and Power Co. have a development at Calumet on the Little Nation River in Quebec, whence they supply, by means of a 10,000 volt transmission, Grenville in Quebec and Hawkesbury and Vankleek Hill in Ontario. It is understood that as relating to Cornwall, an agreement between the St. Lawrence Power Co. located at Mille Roches, 5 miles west of the town, and the Stormont Electric Light & Power Co., of Cornwall, stands in the way of a supply of municipal power to the people of this town, whose natural source of supply is at Mille Roches. The City of Ottawa is supplied from Chaudiere Falls by two systems of distribution, owned one privately and one municipality, the latter obtaining its power from a privately owned generating equipment in Hull, Que., the former generating its own power in Ontario.

A considerable market for electric power and light has developed recently in the Temiskaming district, where are the three towns of New Liskeard, Haileybury and Cobalt and where there is a rapidly growing demand for electric power for the numerous services connected with mining operations.

The following Table V. is a summary showing the variety of frequencies now in use in places in this district:

TABLE V.

Frequency.	Capacity K.W.	Used in.
60	17,745	Eleven towns and cities.
66	100	One town.
100	60	One town.
125	810	Five towns.
133	740	Three towns.

A frequency of 60 cycles per second has been chosen for purposes of the estimates following, as this frequently is in use already in serving a large majority of the urban population of the district and, as it harmonizes with the great bulk of the practice on this continent. This frequency is also satisfactory for all services and well within proper limits for transmission of the relatively small quantities of current to be transmitted, considering the greatest distance estimated upon is only 86 miles. The distances however, are great enough to prohibit the use of any frequency much in excess of 60. This fact must be borne in mind in estimating the cost of distribution for Prescott, Smith's Falls, Carleton Place and Perth, where, 125 and 133 cycle machinery is in use, and where it will be necessary, therefore, to install frequency changers, in addition to the ordinary sub-station equipment.

A proper estimate of the probable immediate future demands for electric power, which demands may be conveniently supplied from available water power developments, is peculiarly difficult on account of the number and character of the many hydro-electric plants now in service, but for the towns in the Southern portion of the district, some optional schemes have been developed. These include proposals to develop, (1) a twelve foot head at Iroquois, Ont., on the Galops canal for the supply of Brockville and Prescott; (2) a seventy-eight foot head at High Falls on the Mississippi River for (a) the supply of Prescott, Brockville, Carleton Place, Smith's Falls and Perth; (b) the supply of Carleton Place, Smith's Falls and Perth only; (c) a twenty-seven foot head at Fountain Falls on the Montreal River for the supply of the Cobalt Mines and Haileybury.

(1) IROQUOIS, ONT., DEVELOPMENT: This scheme involves the use of a power site already partially prepared by the Dominion Government when rebuilding the Galops canal. Water would be taken from just above the lock at the foot of the canal. Twelve feet at periods of high water in the St. Lawrence would be the probable minimum head. The capacity of such a plant would be limited by the maximum discharge of water permitted by the canal authorities and by the continuous flow of water already in service for power and canal purposes. There would be only a small peak load capacity in such a development.

As it is the practice of the management to close the canal periodically, it would be necessary to instal for power purposes an auxiliary steam plant of capacity equal to that of the hydraulic plant here estimated upon, but as it would be desirable that such steam plant or plants should be located in the cities where power is to be delivered, the costs and charges thereon are not estimated. Such reserve plants are those already in service at Brockville and Prescott. The water power conditions at this point will not admit of any considerable addition to the installation herein estimated upon, which is 1,200 H.P.

(2) HIGH FALLS DEVELOPMENT: The developments at this point here estimated upon are for (a) 2,400 horse power and (b) 1,100 horse power, respectively. The natural head at this point is seventy-two feet, which can be augmented, at least six feet, by drowning out small rapids above the falls. It will be noted that in Table IV. above the minimum capacity is given as 900 H.P. under present natural conditions. This capacity can be considerably increased by developing the unusually good storage facilities in the sources of the river, thus permitting an output, as suggested in Scheme A.

Should the market for power grow beyond the capacity of this water power, it would be feasible to develop Ragged and Island Chutes immediately up stream, which would, as one plant, be capable of like output.

(3) FOUNTAIN FALLS DEVELOPMENT: By use of a dam, whose crest would rise nine feet above present head water level, a twenty-seven foot head would be available, giving a minimum output of 1,750 horse power. Survey of the market has shown that there is installed or about to be installed in the mining district, 3,000 boiler horse power. Hydraulic development of 2,400 horse power capacity has been here estimated upon, and such a plant can, in view of the irregular nature of the load, carry the present probable demand.

In estimating the annual charges on this development and transmission, it has been kept in mind that the market being that of a mining camp, is of fluctuating character. On this account, the sinking fund charges have been calculated on a ten year basis, instead of thirty years, as is the case in towns in other portions of the Province, where the prospects of a future market are more assured. Also it is important to note that in the case of the Fountain Falls development, the sinking fund charges have been incorporated in the development and transmission cost per horse power and are consequently included in the final cost per horse power as given in the Summation Sheet.

TABLE VI.

ESTIMATED CAPITAL COST OF POWER DEVELOPMENTS.

LOCATION OF WATER POWER.	Head.	Net Amount of High Tension Power Generated H.P.	Total Capital Cost.	Cost Per H.P.
St. Lawrence River, Iroquois, Ont.	12	1,200	$179,000	$149.16
Mississippi River, High Falls, Ont., A	78	2,400	195,000	81.25
Mississippi River, High Falls, Ont., B	78	1,100	123,000	111.82
Montreal River, Fountain Falls, Ont	27	2,400	214,000	89.16

The capital cost in each case includes step-up transformer stations, one reserve generating unit in excess of each of the above mentioned capacities, and a spare transformer in each station.

TABLE VII.

ESTIMATED ANNUAL CHARGES ON FULLY DEVELOPED GENERATING PLANTS.

ITEMS	St. Lawrence River Iroquois	Mississippi River High Falls Scheme A	Mississippi River High Falls Scheme B	Montreal River Fountain Falls
Operating Expenses including Step-up Transformation Losses	$6,864	$9,391	$6,390	$9,850
Maintenance and Repairs	5,119	3,840	2,491	3.903
*Replacement Fund	5,118	3,841	2,491	21,622
Interest at 4%	7,151	7,777	4,908	8,539
Total Annual Charges	24,252	24,849	16,280	43,914
MUNICIPALITY	Distribution of Charges			
Brockville	$19,681			
Prescott	4,571			
Brockville	.....	$10,629		
Prescott	.....	2,532		
Smith's Falls	.....	5,818		
Carleton Place	.....	3,507		
Perth	.....	2,363		
Carleton Place	.....	.....	$4,927	
Smith's Falls	.....	.....	8,083	
Perth	.....	.....	3,270	
Haileybury	.....	.....	.....	$ 3,704
Cobalt	.....	.....	.....	25,634
Kerr Lake	.....	.....	.....	14,576

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*In the case of Fountain Falls, the figure under this head includes a 10 year sinking fund, of which mention has been made elsewhere in the report.

PART V.

TRANSMISSION OF POWER.

In connection with the hydraulic developments in the Ottawa Valley and that portion of the Province bordering on the St. Lawrence river, four transmission schemes have been considered; viz., one, 20,000 volts, three-phase, from Iroquois through Prescott to Brockville; one, 30,000 volts, three-phase, (Scheme A.) from High Falls through Perth and Smith's Falls to Brockville, Prescott and Carleton Place; one, 20,000 volts, three-phase, (Scheme B.) from High Falls through Perth and Smith's Falls, terminating at Carleton Place; one, 20,000 volts, three-phase, from Fountain Falls through the Cobalt Mining district, terminating at Haileybury.

In the following estimates, the use of high class wooden poles with concrete bases is assumed, the telephone line being mounted on the same poles.

The transmission table shows the capital cost and annual charges on the transmission lines from the step-up transformer station at the various points of development to the step-down stations at points of local distribution. The annual charges include depreciation and repairs, interest and cost of patrol.

The table of transformation details gives particulars concerning the proposed transformer stations. In all cases the step-up station is assumed as being built for full capacity at the outset, with equipment to be installed as required. The transformation charges provide for municipal taxes on building, insurance, depreciation, engineering and contingencies and interest during construction.

The summation sheet contains the charges for transmission, transformation and administration chargeable to each municipality, in addition to which is added in each case, the cost of power at the generating station. The final column is for 24 hour power at low-tension bus-bars of the various municipal sub-stations.

In connection with the transformation and summation sheets, it has not been considered advisable to discuss the question of three-quarter and half loads, as in former reports. If information in this connection should be required, the cost per horse power may be arrived at approximately by dividing total annual charges for any town by the amount of power delivered there.

Smith's Falls.		Perth.		Haileybury.		Cobalt.		Kerr Lake.	
Loss of Power.	Annual Charges.	Loss of Power.	Annual Charges.	Loss of Power.	Annual Charges.	Loss of Power.	Annual Charges.	Loss of Power.	Annual Charges.
H.P.		H.P.		H.P.		H.P.		H.P.	
11.8	$ 571								
23.1	912	9.2	$371						
34.9	$1,483	9.2	$371						
14.4	1,298								
27.61	1,931	11.2	782						
42.0	$3,229	11.2	$782						
...	.....	....	...	1.0	$ 739				
...	.....	....	...	1.5	79	9.7	$ 537		
...	.....	....	...	5.7	256	39.1	1,744	22.2	$991
...	.....	....	...						
				8.2	$1,074	48.8	$2,281	22.2	$991

TABLE IX.

TRANSFORMATION DETAILS.

MUNICIPALITY.	Capacity H.P.	Capital Cost.					Annual Charges.				Source of Power.
		Building and Lot.	Equipment.	Engineering and Contingencies 10 per cent.	Interest during Construction 2 per cent.	TOTAL.	Maintenance and Depreciation.	Interest 4 per cent.	Operating.	TOTAL.	
Brockville...........	875	$2,100	$12,620	$1,472	$324	$16,516	$782	$661	Operating cost covered by line patrol and administration.	$1,443	Iroquois, Ont., 20,000 Volts.
Prescott............	208	1,100	8,340	944	208	10,592	550	424		974	
Brockville...........	875	2,100	18,600	2,070	455	23,225	1,110	929		2,039	High Falls, Mississippi River, Scheme A, 30,000 Volts.
Prescott............	208	1,100	8,270	937	206	10,513	496	420		916	
*Smith's Falls.......	504	1,600	17,042	1,864	410	20,916	1,122	836		1,958	
Carleton Place.......	300	1,100	10,023	1,112	244	12,479	631	499		1,130	
Perth..............	210	1,100	11,145	1,224	269	13,738	659	550		1,209	
Carleton Place.......	300	1,100	9,470	1,057	233	11,860	582	475		1,057	High Falls, Mississippi River, Scheme B, 20,000 Volts.
*Smith's Falls.......	504	1,600	14,160	1,576	347	17,683	852	707		1,559	
Perth..............	210	1,100	9,970	1,107	243	12,420	570	497		1,067	
Haileybury..........	200	1,100	9,520	1,062	234	11,916	566	477		1,043	Fountain Falls, Montreal River, 20, 000 Volts.
Cobalt.............	1,400	2,100	22,675	2,477	545	27,797	1,307	1,112		2,419	
Kerr Lake..........	800	2,100	17,020	1,912	420	21,452	1,022	858		1,880	

*Switching Station.

TABLE X.

SUMMATION SHEET

Municipality.	Population.	Present Power Used.		Estimated Future Load.	Annual Charges.					Total Annual Cost of 24 Hour Power at Low Tension Bus-bars, Step-down Transformer Station.	Source of Power.
		Total.	Portion admitting Electrical Installation.		Generation including Step-up Transformation	Transmission.	Step-down Transforma-tion.	Administra-tion and Interswitching	Total.		
Brockville	9,000	700	700	875	$19,681	$4,430	$1,443	$2,935	$28,489	$32.55	Iroquois, Ont. 20,000 Volts.
Prescott	3,035	215	150	208	4,571	535	974	665	6,745	32.42	
Brockville	9,000	....	....	875	10,629	6,359	2,039	3,498	22,525	25.68	High Falls, Mississippi River, Scheme A, 30,000 Volts.
Prescott	3,035	....	....	208	2,532	3,337	916	828	7,613	36.58	
Smith's Falls	5,700	815	300	504	5,818	1,483	1,958	1,931	11,190	22.20	
Carleton Place	4,000	505	175	300	3,507	3,773	1,130	1,157	9,567	31.89	
Perth	4,000	240	150	210	2,363	371	1,209	785	4,728	22.51	
Carleton Place	4,000	....	....	300	4,927	5,047	1,057	1,515	12,546	41.82	High Falls, Mississippi River, Scheme B, 20,000 Volts.
Smith's Falls	5,700	....	....	504	8,083	3,229	1,559	2,480	15,351	30.45	
Perth	4,000	....	....	210	3,270	782	1,067	1,005	6,124	29.16	
Haileybury	1215,	200	200	400	3,704	1,074	1,043	507	6,328	31.64	Fountain Falls, Montreal River, 20,000 Volts.
Cobalt	Indef.	1,800	1,400	2,800	25,634	2,281	2,419	3,503	33,837	24.17	
Kerr Lake	Indef.	1,000	800	1,600	14,576	991	1,880	1,990	19,437	24.29	

In the following table (XI.) is shown in condensed form the investment and annual charges for transmission and step-down transformation, also the cost per annum per horse power ready for distribution from the low-tension bus-bars in the various towns.

TABLE XI.

ITEMS	St. Lawrence River Iroquois	Mississippi River		Montreal River Fountain Falls
		High Falls Scheme A	High Falls Scheme B	
Total H.P. Distributed	1,200	2,366	1,100	2,400
Total Investment including Step-down Transformer Stations	$89,802.00	$252,683.00	$142,555.00	$118,427.00
Investment per H.P. delivered	74.86	110.90	129.60	49.34
Total Annual Repairs, depreciation, operation and administration	3,790.00	13,299.00	8,039.00	4,951.00
Interest 4%	3,592.00	10,107.00	5,702.00	4,737.00
Total	7,382.00	23,406.00	13,741.00	9,688.00
MUNICIPALITY	Cost of 24 hour power per H.P. per Annum including line and step-down transformer losses.			
Brockville	$32.55			
Prescott	32.42			
Brockville	.....	$25.68		
Prescott	.....	36.58		
Smith's Falls	.....	22.26		
Carleton Place	.....	31.89		
Perth	.....	22.51		
Carleton Place	.....	.....	$41.82	
Smith's Falls	.....	.....	30.45	
Perth	.....	.....	29.16	
Haileybury	.....	.....	.....	$31.64
Cobalt	.....	.....	.....	24.17
Kerr Lake	.....	.....	....	24.29

INDIVIDUAL TRANSMISSION.

The various sub-stations have been estimated on the basis of transformation down to 2,200 volts, but the cost of distribution of power at this voltage will be dealt with in Part VI. Many instances arise, however, in which it is desired to supply a single large consumer or a small municipality at some distance from a sub-station. When this is the case the following table may be made use of. The total cost of power to such a consumer is ascertained by adding the rate per H.P. from this table to the cost of power at the nearest municipal sub-station. The charges for such a branch transmission do not include any allowance for right of way or telephone, it being assumed that the highways would be available for such low voltage lines.

TABLE XII.

SHOWING COST OF DISTRIBUTION FROM MUNICIPAL SUB-STATION TO AN INDIVIDUAL CONSUMER, NOT COVERED BY LOCAL DISTRIBUTION.

Distance in Miles from Municipal Sub-station.	Cost per Horse-Power per Annum for the Delivery of Various Amounts of Power.							
	50 H.P.	75 H.P.	100 H.P.	150 H.P.	200 H.P.	250 H.P.	300 H.P.	
2	$5.58	$4.20	$3.53	$2.92	$2.74	$2.60	$2.51	2,200 Volts
3	6.89	5.20	4.41	3.60	3.25	3.10	3.03	
4	7.92	6.18	5.20	4.27	3.93	3.72	3.86	
5	8.87	7.18	5.98	4.96	4.55	4.32	4.17	
6	10.20	8.24	6.77	5.38	5.13	4.60	4.43	
8	14.10	10.14	8.40	6.97	6.24	5.79	5.58	11,000 Volts
10	16.12	12.13	9.54	8.31	7.68	6.96	6.17	
12	18.76	14.03	11.12	10.12	8.42	7.96	7.22	16,500 Volts
15	22.74	17.08	13.48	10.89	9.35	8.84	8.32	

PART VI.

DISTRIBUTION OF POWER.

The cost of distribution from the municipal sub-stations to the consumers' premises varies widely with different conditions and depends upon the distances involved, the magnitude of the demands of individual consumers, and the grouping of these consumers.

This cost of distribution will not necessarily, however, give the increase of cost to the consumer above that paid for the power by the municipality unless a method of charging be chosen which will take into account the difference between the sum of the consumers' maximum demands and the maximum demand on the station. If the charging rate for power were one composed of a flat rate based on maximum demand plus a rate per k.w.-hour or h.p.-hour actually registered by meter, then it would be approximately correct to say that the combined rate per horse power to the consumer should be the same as the cost of power at the sub-station plus the cost per horse power of the distribution service. Besides this the ordinary municipality has such various means of modifying the rates for power, such as limited-hour contracts with motor users, contracts with summer users of electric power, etc., that fair rates could only be established after a careful study of the actual conditions after operations were begun. Under average conditions in a town demanding 1,000 H.P. or over, it could reasonably be expected that 10-hour power could be sold at the same or even a lower rate, if based on maximum demand than that charged the municipality for 24-hour power at the sub-stations. In other words, the municipality might expect to profit sufficiently from non-coincident peaks, 24-hour power for lighting, pumping, general motor users, etc., to pay the cost of its distribution.

The cost of a distribution system for the town of Brockville has been estimated on, the same being entirely independent of the one in use at the present time. This includes completely equipped pole and distribution lines and sufficient 2,200 volt 60 cycle power service transformers to carry the present motor load. Two banks of 2,200 volt transformers have been assumed in this estimate as centrally located in the town from which the lighting load would be taken, but it is important to note that this estimate does not include the cost of lighting, distribution and lighting transformers. On this basis, it is found that the total capital cost will be about $21,000 and the annual interest, depreciation and operation charges attendant upon this investment would be $4,100.00. This charge on 950 H.P. gives a yearly rate of $4.30 per H.P., which, added to the cost of low-tension power at the sub-station, as given in Table X., gives an average yearly rate for 24 hour power, without any allowance for over-lapping. It is probable that if suitable portions of the present distribution system were utilized, the capital cost would be materially reduced.

In connection with the smaller towns, it may be said that the actual selling price of 10 hour power to the consumer would not be appreciably greater than the cost of 24 hour power to the municipality at the main sub-station, as given in the Report, if the facilities for the double use of power be at all favorable.

PART VII.

MOTOR INSTALLATIONS.

To complete the information regarding the cost of electric power to the consumer, the following table is given, showing the cost of induction motor service per H.P. per year.

TABLE XIII.

Capital Cost and Annual Charges on Motor Installations, Polyphase, 60-Cycle Induction Motors.

Capacity. H.P.	Capital Cost per H.P. Installed.	ANNUAL CHARGES.			
		Interest 5%	Depreciation and Repairs, 6%	Oil, Care and Operation.	Total per H.P. per Annum.
5	$39.00	$1.95	$2.34	$4.00	$8.29
10	36.00	1.80	2.16	3.00	6.96
15	30.00	1.50	1.80	2.50	5.80
25	25.00	1.25	1.50	2.00	4.75
35	22.00	1.10	1.32	1.75	4.17
50	20.00	1.00	1.20	1.50	3.70
75	19.00	.95	1.14	1.25	3.34
100	17.00	.85	1.02	1.00	2.87
150	15.00	.75	.90	.80	2.45
200	14.00	.70	.84	.70	2.24

By combining the costs given in this table with the cost of distributed power, as indicated in Part VI, the final or total charge per H.P. per year will be obtained.

PART VIII.

SINKING FUND.

In the above estimates for transmission and transformation, depreciation and replacement charges have been provided for which would replace the different classes of plant in periods ranging from 15 to 30 years. These charges would, therefore, amply serve the purpose of any sinking fund which might be considered needful. In the case of the generating plant estimates, however, these charges would not be sufficient for such a purpose in the so-called permanent portions of the development, comprising the dam, headworks, powerhouse, etc.

A forty year sinking fund to cover these portions of the development, amounting on the average to about $35.00 expenditure per H.P.

of capacity, would require a charge of 37 cents per H.P. to repay this expenditure in 40 years, interest being calculated at 4 per cent.

The special conditions governing the case of the Fountain Falls development have been set forth elsewhere in the Report.

PART IX.

EXISTING RATES.

In Table XIV. following will be found a statement of the lighting and power rates in a number of municipalities throughout the District.

PART X.

STEAM POWER.

In order to institute a comparison between the cost of electric power as has just been set forth and the cost of power generated by steam or producer-gas, the following tables have been compiled after a careful study of data available in technical journals and also from data collected by the Commission's engineers in various towns within the district under consideration. The capital costs have been compiled from information supplied by various makers of engines and other machinery. The tables represent average working conditions and assume a high class installation.

TABLE XV.

STEAM POWER PLANTS.

SHOWING CAPITAL COSTS OF PLANTS INSTALLED AND ANNUAL COSTS OF POWER PER BRAKE HORSE-POWER.

Size of Plant, H.P.	Capital Cost of Plant per H.P. installed.			Annual Cost of 10-hour Power per B.H.P.	Annual Cost of 24-hour Power per B.H.P.
	Engines, Boilers, etc., installed.	Buildings.	Total.		
	CLASS I.—Engines: Simple, slide valve, non-condensing. Boilers: Return tubular.				
10	$66.00	$40.00	$106.00	$91.16	$180.76
20	56.00	37.00	93.00	76.31	151.48
30	48.70	35.00	83.70	66.46	131.68
40	44.75	33.50	78.25	59.49	117.74
50	43.00	31.00	74.00	53.95	106.46
	CLASS II.—Engines: Simple, Corliss, non-condensing. Boilers: Return tubular.				
30	70.70	35.00	105.70	61.14	117.70
40	62.85	33.50	96.35	55.50	107.10
50	59.00	31.00	90.00	50.70	97.73
60	56.00	30.00	86.70	47.42	91.34
80	50.00	27.50	77.50	43.86	85.41
100	44.60	25.00	69.60	40.55	79.19
	CLASS III.—Engines: Compound, Corliss, condensing. Boilers: Return tubular with reserve capacity.				
100	63.40	28.00	91.40	33.18	60.05
150	53.70	24.00	77.70	29.83	54.63
200	50.10	20.00	70.10	28.14	51.72
300	45.90	18.00	63.90	26.27	48.83
400	43.55	16.00	59.55	24.84	46.12
500	41.25	14.00	55.25	23.73	44.21
750	40.50	13.00	53.50	23.56	44.02
1000	39.00	12.00	51.00	23.26	43.71
	CLASS IV.—Engines: Compound, Corliss, condensing. Boilers: Water-tube, with reserve capacity.				
300	55.20	18.00	73.20	25.77	46.32
400	51.50	16.00	67.50	24.18	43.61
500	49.40	14.00	63.40	23.19	42.03
750	46.80	13.00	59.70	22.88	41.56
1000	44.30	12.00	56.80	22.47	41.11

NOTE:—Annual costs include interest at 5 per cent., depreciation and repairs on plant, oil and waste, labor and fuel (coal at $4.00 per ton). Brake horse-power is the mechanical power at engine shaft.

It will be noted that for a consumer requiring a large installation, operating for ten hours only, there appears to be little advantage to be derived from the use of transmitted electric power, provided the power is not to be distributed throughout a consumer's buildings by a complicated system of shafting, belts, etc. But in the majority of cases this condition obtains, and herein lies one of the specific advantages of electric power. Motors can be installed on each floor of the factory, or even on each machine, with but little loss in efficiency, and only such motors as are required to drive the machinery in use from time to time need be operated. In many cases due to this fact the total electric power consumption of a large factory would be reduced from 25 per cent. to 50 per cent. below that which is required under steam operation, working from a central station.

Again, where electric power is available throughout the 24 hours many industries will work night and day, thereby effecting a great economy, as is evidenced by a comparison of the cost of 24-hour steam or producer-gas power with 24-hour electric power.

Perhaps the most striking advantage to be derived from the use of electric power as compared with other power, is that the small consumer can obtain power at a rate which should not be appreciably greater than that made to the large consumer, although the present practice in selling electric power is to discriminate against the small consumer for the reason that electric power prices made by private companies are not based on cost of service, but are merely made with a view to displacing steam.

PART XI.

PRODUCER GAS POWER.

TABLE XVI.

Showing Capital Costs of Producer Gas Plants Installed, and Annual Costs of Power per Brake Horse-power.

Size of Plant, H.P.	Capital Cost of Plant per H.P. Installed.			Annual Cost of 10-hour Power per B.H.P.	Annual Cost of 24-hour Power per B.H.P.
	Machinery, etc.	Buildings.	Total		
10	$137.00	$40.00	$177.00	$53.48	$90.02
20	110.00	36.00	146.00	44.47	75.22
30	93.00	33.00	126.00	38.73	65.99
40	84.50	29.00	113.50	35.05	59.85
50	80.00	26.00	106.00	32.27	55.22
60	79.00	24.00	103.00	30.49	52.03
80	78.20	22.00	100.20	28.70	48.95
100	77.50	20.00	97.50	27.05	45.40
150	76.00	19.00	95.00	25.87	43.17
200	74.00	17.00	91.00	24.95	41.78
300	73.00	16.00	89.00	24.24	40.40
400	71.50	14.00	85.50	23.41	39.03
500	70.00	12.00	82.00	22.54	37.54
750	67.50	10.00	77.50	21.55	35.99
1000	65.00	8.00	73.00	20.46	34.66

Note.—Annual costs include: Interest at 5 per cent., depreciation and repairs on plant, oil and waste, labor and fuel (bituminous coal at $4.00 and anthracite coal at $5.00 per ton).

A reference to Table XV. will show that the cost of power developed by producer-gas plants and gas engines is less than that produced by steam plants of the same capacity. It may be said, however, that up to the present no very large installations of suction producers have been made, 250 to 300 horse-power being about the maximum. But this has been provided for in the table by assuming that the larger plants will be made up of several units, each unit being not greater than 350 H.P. capacity. While operation of producer-gas plants has not been going on many years, and complete knowledge on the subject is not available, with the information at hand it is believed that in many situations this form of power producer will be found more economical than a steam plant, and, there-

fore, a closer competitor of hydro-electric power. It must be r
bered that the same objections hold against the producer-gas pl
those which have been mentioned in reference to steam plants; na
that 24-hour power costs proportionately more than 10-hour po
that the small consumer does not have the great advantage obtain
by the use of electric power; and also that a central installatio
a factory is all that is possible if electric motors are required
various parts of the factory, and the only prime mover available
steam or gas. This will make the cost of electric factory operati
very expensive, and considerably higher than the power costs show
in Table XI. Speaking generally, however, it may be said that pr
ducer-gas plants have a bright future, and as the design and con
struction is perfected undoubtedly the capital cost will be reduced
and the cost of power lessened.

TABLE XVII.

SHOWING THE EFFECT ON THE COST OF POWER OF A VARIATION IN THE PRICE OF COAL OF ONE-HALF DOLLAR PER TON.

Size of Plant. H.P.	Suction Producer Gas.		Steam.		
	10-Hour.	24-Hour.	10-Hour.		24-Hour.
10	$1.15	$2.53	Simple Slide Valve Engine.	$6.14	$13.47
20	1.13	2.46		5.25	11.56
30	1.10	2.40		4.71	10.35
40	1.07	2.33		3.56	7.84
50	1.04	2.29	Simple Automatic Non-condensing.	3.37	7.41
60	1.01	2.24		3.26	7.16
80	.98	2.18		3.15	6.97
100	.96	2.12		3.12	6.87
150	.94	2.07	Compound Condensing.	1.75	3.85
200	.92	2.02		1.69	3.71
300	.90	1.98		1.62	3.60
400	.88	1.94		1.56	3.44
500	.86	1.89	Compound Condensing; Water-tube Boilers.	1.39	3.05
750	.82	1.81		1.39	3.05
1,000	.76	1.72		1.39	3.05

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